SYSTEM AND METHOD FOR CORRECTING ERRORS IN DEPTH FOR MEASUREMENTS MADE WHILE DRILLING

FIELD OF THE INVENTION:

5   The present invention relates to the field of measurements made during the drilling phase of a hydrocarbon borehole. In particular, the invention relates to an automated method for correcting errors in depth for such measurements.

10

BACKGROUND OF THE INVENTION:

         During the drilling phase of the construction of a hydrocarbon wellbore, the length of the drillstring
15   in the borehole is used to estimate the measured depth (or along hole length) of a borehole, it is assumed that the pipe is inelastic and therefore does not stretch. However, discrepancies in the length of the borehole estimated at surface during rig operations and the actual
20   length of the borehole there may cause gaps or lost data, when the uncorrected depth is used with logs of data measured during with sensors mounted on the drillstring, such as LWD and MWD logs.

25

SUMMARY OF THE INVENTION:

         According to the invention a method is provided for automatically correcting for depth errors in
30   measurements taken from a drillstring comprising the steps of receiving data representing measurements taken in a hydrocarbon wellbore at a plurality of depths within

the wellbore from at least one sensor located on a
drillstring used to drill the wellbore, automatically
calculating corrections for errors in the depth of the
locations, and making use of the measured data having the
5   depths corrected.

BRIEF DESCRIPTION OF THE DRAWINGS:
        Figure 1 shows a scheme for correcting depth
10   for measurements made from a drillstring according to a
preferred embodiment of the invention;
        Figure 2 shows an example of data prior to
correction according to a preferred embodiment of the
invention; and
15   Figure 3 shows data that has been corrected
according to a preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION:
20

        The length of the drillstring in the borehole
is used to estimate the measured depth (or along hole
length) of a borehole. According to the invention, the
depth is corrected. For real drill strings the assumption
25   that the drillstring is inelastic is not valid. The
length of the drillpipe is a function of several
parameters including temperature, pressure, and stress.
According to the invention, corrections are calculated
based on at least the stress on the drillstring. In
30   particular, a correction is calculated based on the un-
deformed length of the drillstring and the stress due to
the buoyant drillstring weight, weight on bit and

frictional forces due to contact with the borehole acting
along the length of the drillstring. Two of these
parameters, friction factor and weight on bit vary
depending on the rig operation and the drillers input at
5   surface. According to the invention, a method is provided
for correcting the measurement of depth at surface for
these parameters. The corrected depth is then used to
assign depths to data measured downhole.

10   Figure 1 shows a scheme for correcting depth
for measurements made from a drillstring according to a
preferred embodiment of the invention. According to a
preferred embodiment of the invention the following steps
are undertaken for each time step:
15

                1) The drillstring description, dimensions pipe
weight per unit length are input, the pipe length as
measured at surface is updated from real-time
measurements.
20   2) The borehole trajectory, inclination and
azimuth are input and updated from downhole measurements
in real-time.
                3) The rig operation is computed preferably as
described in co-pending US Patent Application Serial No.
25   10/400,125 entitled "System and Method for Rig State
Detection," filed on 26 March 2003; which is a
continuation-in-part of co-pending US Patent Application
Serial No. 10/330,634 filed on 27 December 2002. Both of
these applications are hereby incorporated herein by
30   reference.
                4) A model for computing the stress in the
drillstring is selected.

5) A friction factor is selected for the given rig state.

6) Weight on bit is either estimated from the hookload and total hookload or from weight on bit

5   measured downhole.

7) From these inputs the model is used to compute the hookload. If the hookload is within tolerances equal to the measured hookload the stress profile is accepted and used to compute the pipe stretch.

10   If it is not then the friction factor or the weight on bit are varied until the hookload and the calculated hookloads match. The models used here and in step 4 above preferably known models such as Drillsafe™.

8) Pipe stretch is then computed using the

15   stress profile.

9) The stretch correction is applied to measured depth to give the corrected depth and time stamped.

10) Time stamped downhole data is the

20   associated with the corrected surface measured depths with the same time stamp.

Figure 2 shows an example of data prior to correction according to a preferred embodiment of the

25   invention. The first frame of Figure 2 shows a surface time verse depth plot, the first section is drilling without surface rotation. As a result all of the friction force is opposing the motion of the drillsting along the hole. As a result whilst drilling the direction of the

30   friction force is towards surface. The driller then stops drill pulls the drillstring off bottom and then runs back to bottom rotating the drillstring, when rotating the

friction force opposes the direction of rotation and as a
result the frictional force along the borehole falls to
close to zero. This results in an increase in the tension
in the pipe and therefore an increase in the pipe stretch
5   as a result the position of the bottom of the hole as
measure from surface appears shallower. In the second
frame the resistivity data are shown plot against the
same time scale. In the third frame the resistivity data
are plotted against the apparent depth at which they were
10   measured. It can be seen that there is a section of data
in lighter grey that in terms of depths overlaps
previously recorded data. Conventionally, these data
would be discarded. The darker line represents the data
that would be kept. Thus, failure to compensate for
15   errors in depth results not only in lost data but also
the thickness of the formation section appearing thinner.

Figure 3 shows data that has been corrected
according to a preferred embodiment of the invention.
The stress profile and the pipe stretch have been
20   calculated according to an appropriate model for the rig
operation. Note that in the first frame, the depth at
which drilling resumes is very close to the depth at
which it stopped. Secondly, the measured resisitivities
are properly allocated to the measure depth. Thus,
25   according this embodiment of the invention, there is no
loss of data or gaps, (the remaining grey points are
recorded off bottom).

While the invention has been described in
30   conjunction with the exemplary embodiments described
above, many equivalent modifications and variations will
be apparent to those skilled in the art when given this

disclosure. Accordingly, the exemplary embodiments of
the invention set forth above are considered to be
illustrative and not limiting. Various changes to the
described embodiments may be made without departing from
5   the spirit and scope of the invention.